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# GRANGER CAUSALITY TEST FOR THE RELATIONSHIP BETWEEN HOUSE AND LAND PRICES

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## ABSTRACT

*This paper uses a Granger causality estimate to assess whether the theoretical Ricardian understanding of the relationship between house and land prices is valid in a dynamic urban land market. The paper compares a Site Adjusted Land Price Index with an equivalent Quality Adjusted Housing Price Index developed for Adelaide, the state capital of South Australia for the period 1985 to 2010. The study clearly identifies the increasing gap in the rate of growth between vacant land and detached house prices for a metropolitan area and concludes that house prices Granger cause land prices but not that land prices Granger cause house prices.*

## KEYWORDS

Housing Market, land pricing, time series analysis, granger causality

## INTRODUCTION

In Australia a number of agencies have called for greater research into the relationship between land and house prices including the Australian Housing Supply Council (2009; 2010), the Australian Property Council (2007) and the Housing Industry Association (HIA) (2009). A key rationale for the reporting of land prices lies within the context of housing affordability. One factor considered critical to the determination of housing affordability is land costs in that cheaper land should result in a more affordable housing market. In the recent government literature (Housing Supply Council, 2009; 2010) and invariably in the industry material (Moran, 2008; Day, 2009; UDIA, 2009; APC, 2007) the link between rising land prices across Australia and rising house prices is understood to be fundamental. A first step in understanding the relationship between land and house prices, however, is an appropriate land price index. While the establishment of median house prices and a hedonic house price index is well researched (Rossini, 2002, 1996; Rossini & Kershaw, 2006), the construction of a vacant land index is significantly more problematic. Substantially more vacant urban land is sold only once as a vacant site (after which it is developed) and greater percentages are sold in multiple transactions and under circumstances which might be considered non-market. In this study a Site Adjusted Land Price Index is first constructed and then compared to an equivalent Quality Adjusted Housing Price Index as a means of establishing any relationship between the two indexes. The analysis is undertaken for Adelaide the state capital of South Australia for a 25 year time period from 1985 to 2010. The metropolitan area of Adelaide has been selected as a case study for the construction and analysis of the land price index as it is recognized by the development industry as one of the best managed capital cities in terms of vacant land supply (HIA, 2009) within Australia.

## LITERATURE

Government inquiries into housing affordability in Australia have recognised the key role that demand drivers, such as income levels, cheaper finance, and population growth play in determining house prices. Both the Productivity Commission into First Home Ownership (Australian Government Productivity Commission 2004) and the Reserve Bank of Australia (RBA) (Ellis 2006) were of the opinion that a general surge in demand had led to a widespread escalation in house prices with Ellis (2006) concluding that an “untrammelled supply of extra dwellings would not have prevented a large increase in Australian house prices over the last decade”. Ellis (2006), Otto (2007) and Costello and Rowley (2009) have all identified a weak or non-existent relationship between land supply and house price growth. Yet, according to recent government literature (National Housing Supply Council, 2009) and industry material (Moran, 2006; Day, 2009; UDIA, 2009; PCA, 2007) rising house prices across Australia are understood to be fundamentally a result of rising land prices through restricted land supply. This is despite the general recognition that the rate at which new houses can be built (the flow of housing) is very small relative to the existing stock of dwellings (approximately 2 per cent) and that as a result house prices across the wider Australian economy could rise or fall irrespective of what is happening to the supply of new homes (Ellis, 2006).

The theory of land pricing is based on the model developed by David Ricardo who in the 19th century suggested that the fundamental value of land was derived from the returns, or 'rent' surplus that it produced. Ricardo offered what was then the revolutionary idea that the price that was paid for land was determined by the returns that could be achieved from it. Inherent in the Ricardo model is the assumption that land is inelastic in supply, that in time it will be given over to its optimum use and that the expectation of returns from land drive the level of demand. Within the Ricardian approach land is said to have value whereas housing or other so called improvements merely add value. This Ricardian model was later supplemented by the neoclassical approach which recognised that both demand and supply factors worked together to achieve an equilibrium point in terms of price (Evans, 2004). However the neoclassical approach also assumes that land supply is not restricted and that all sites have potentially a variety of uses both of which run contrary to most modern planning regimes. The Ricardo concept of 'rent' surplus was used by Alonso (1964) and Muth (1969) to identify land values as being the result of development value minus development costs and required profit margin. This approach has become more generally known as the residual, development or hypothetical form of land valuation and is traditionally understood to be the technique used by developers to formulate their expectation of value, costs and financial viability (Guy & Henneberry, 2002). The residual method identifies the value of land to be purchased as that amount which is left after all costs plus a profit margin have been deducted from the estimated value of the completed housing development. The residual value identifies for the developer the amount that should be paid for the land which can be compared to the asking price to determine whether the housing development is feasible or not. Developers look to the already existing housing market to establish a likely selling price for their product. Since the supply of houses for sale in an area is usually dominated by established properties (up to 90 per cent) developers are considered to be 'price takers' (Oxley, 2004). From this approach it would seem that the price paid for the land is a function of the expected selling price of the development which has been largely derived from the existing housing market. Hence, following this line of argument, land prices are fundamentally a product of house prices (Appraisal Institute, 1992).

This elemental understanding has been supported in empirical work carried out by Ball (1983), Bramley and Watkins (1996), Dipasquale and Wheaton (1996), Leishman et al (2000), Gillen and Fisher (2002) and Ooi and Lee (2007). While the calculations involved in determining the present value of a staged housing development require considerable financial sophistication, the basic premise remains that land prices are considered a residual after the deduction of development costs and desired profits from predicted revenues (Adams et al, 2009). Thus changes in market activity such as rising or falling prices in the existing housing market should be reflected in prices paid for land. Leishman et al (2000) and Adams et al (2009) have extended the approach by focusing on developer behaviour and suggest that uncertainty and attitudes to risk are key influences on land prices. Developers are considered to be risk averse with bids for land made more on current house prices rather than forecast values. This results in land values being underestimated as uncertainly leads to a collective conservatism (Leishman et al 2000). However the downside of this approach can be that in a constrained land market taking too conservative a view will undermine their chances of success. This is particularly so when demand is strong and house prices are rising. In this environment developers will bid more competitively for land with current prices strong and their profit margins ensured. However if the market turns developments, even with ample land supply, will be mothballed as forecast returns fail to cover even marginal costs (Adams et al 2009). In a falling market price paid for land may be based more on forecast house prices while in a rising market current prices prevail. Thus the housing market cycle impacts directly on developer behaviour and on prices paid for land. And constraints on land supply through planning restrictions or for other reasons can increase expectations of higher house prices, promote competition and drag land prices up (Adams & Watkins, 2002). As such higher land prices are being reflected in higher house prices. Ooi and Lee (2007) suggest that such cross-market interactions cannot be ignored.

This study attempts to examine if any such relationship between house and land can be identified within the Australian land and housing market using the metropolitan area of Adelaide as a case study. After the construction of a land price index the lead lag relationships of a Site Adjusted Land Price Index are compared to an equivalent Quality Adjusted Housing Price Index and tested using Granger causality estimates to assess whether the theoretical concepts as discussed above are valid in a dynamic urban land market.

## METHOD

This paper reports on over 121,833 vacant land transactions for a 30 year time period from 1981 to 2010 and some 404,549 detached dwelling transactions between 1985 (when building size data was available) and 2010 for metropolitan Adelaide. The property transaction data for 1981 to 1992 was obtained from the Valuer General SA and the data from 1993 to November 2010 from the State Government SA and RP Data (2010). The methodology first describes the steps used to clean the data. Next the equations used in the hedonic models to adjust land and house prices to create a Site Adjusted Land Price Index and a Quality Adjusted Housing Price Index are described. Finally the lead lag relationships of the two indexes are tested using Granger causality estimates. This approach is based on the procedure suggested by Engle and Granger (1987) and utilised by Ooi and Lee (2007) in a similar study involving house a land prices in Singapore.

Initially the study adopted the following cleaning processes.

- In each instance "other land", nonmarket transactions and probable commercial-industrial zoned properties were removed.
- In the case of land transaction, size restrictions were then imposed and only land transactions when the land was between 50 m² and 1500 m² were included.
- For housing the same land area restriction was imposed and only properties with a building area between 30 m² and 500 m² were included.
- In addition housing where the sale price was greater than twice the capital assessed value or less than .6 of the assessed value were removed.
- This results in 78% of all sales involving a detached or semi-detached house being included in the analysis and 72% of land transactions.

Next as the only physical attribute available for the vacant land sales was site area in square metres this was used, together with the site area squared to allow for diminishing marginal returns, to produce a Site Adjusted Land Price Index. For housing the building area, building area squared and building age were used to produce a Quality Adjusted House Price Index. The hedonic models use an OLS process with the natural logs of land and house prices regressed against a series of physical attributes for a 30 year time period from 1981 to 2010. This allows the exponents of the beta values to be expressed as premiums. The OLS model is an exponential form consistent with Ooi & Lee (2006) and Ooi, Sirmans & Turnbull (2006).

For both houses and land the models were specified as

$$\ln Y = \ln \beta_0 + \ln \beta_1 d_1 .... \ln \beta_n d_3 + \ln \theta_1 X_1 ..... \ln \theta_3 X_n$$

Where $Y$ = a vector of property transaction prices

$\beta_0$ = a constant

$d_{1...}$ $d_n$ = dummy variable for quarter 1 to quarter n

$\beta_1 \ldots \beta_n$ = price index for quarter 1 to quarter n

$X_1$..X.n= an array of physical attributes

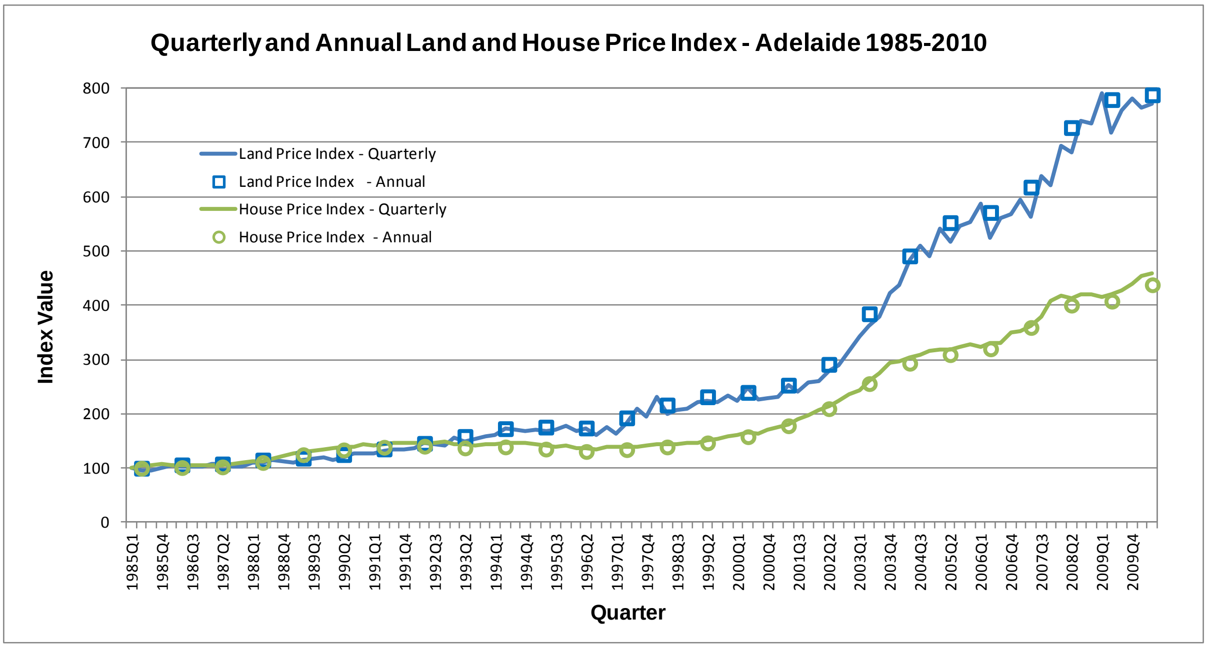
$\theta_1 \ldots \theta_n$ = price index for physical attribute 1 to attribute n

Finally the lead lag relationships between the indexes were tested using a methodology adopted by Engle and Granger (1987) and utilised by Ooi and Lee (2007) in a similar study involving house and land prices in Singapore. Data for this procedure was based on the quarterly hedonic price indices as described above for the period 1985 to 2010. The indices were first converted to natural logarithms to reduce problems with heteroscedasticity and analysed in a series of steps. The first step examined the series using correlograms. These highlight structural components in the data and provide a visual gauge of the likelihood of each series having a unit root. If the data shows signs of non-stationarity the augmented Dicky-Fuller is used to establish if the series are statistically stationary or have unit roots. If the data are stationary then the causal relationship can be established using the original data and the Granger causality test in a Vector Auto regression (VAR) framework. In the event that the data have unit roots the Johansen test for cointegration is used to test if the two series have a long run relationship. If the series are cointegrated the Granger causality test must then be estimated in a restricted VAR known as the Vector Error Correction (VEC) framework.

## RESULTS

When the two indexes are plotted an increasing gap is clearly evident between the rate of growth in vacant land prices as against detached house prices across metropolitan Adelaide (Figure 1). Using 1985 as the base year it shows relative price increases for vacant land and for detached dwellings for the metropolitan area over a 25 year period. There can be no doubt about the rising cost of vacant land relative to detached dwellings on improved sites.

Figure 1 Quality Adjusted House Price Index & Site Adjusted Land Price Index Adelaide




Source Author analysis of SA VG, SA State Government & RPData

The period of the South Australian Government Urban Land Trust from 1981 to 1996, which largely adopted a land banking role, would appear consistent with modest increases in the rate of house price and land price growth. However, as of 1996 and coincidently with the introduction of a more profit orientated South Australian Government Land Management Corporation, there is an increase in the rate of land price growth in metropolitan Adelaide which then escalates in 2001/2002 to surge again in 2007/ 2008. Both these periods are associated with federal and state government subsidies to first home buyers which, overall, tended to inflate house prices, initially at the lower end of the market, but with possible knock on effects throughout the wider housing market Trenwith, 2011; Community Housing Coalition of WA, 2011). Given that increasing house prices could largely determine prices paid for vacant land the link between the two markets appears strong. This hypothesis is tested below.

## Correlograms

Correlograms for the house and land price index are shown in Figure 2 to Figure 5 in the Appendix.

The chart is based on the ordinary data for both series and shows autocorrelations and partial autocorrelations near 1 at a single period lag, with the autocorrelations slowly moving to zero. For both series the correlogram of differenced data show small autocorrelations and partial autocorrelations at one lag that quickly move to zero; all indications that the data is probably stationary at first difference although the autocorrelations for the house price index move more slowly to zero and may imply that second difference are required to induce stationarity. These indicate that the house and land price series are likely to have unit roots.

## Unit Root Tests

The Augmented Dickey Fuller (ADF) test (Table 1) is used to test for the unit root in both series. The results of the test for both the land and house price indexes show that the hypothesis that the series contain unit roots cannot be rejected for the data in its raw form (on the level) but that the hypothesis can be rejected at a 90% level of confidence for the house price index and at the 99% level for land price index in terms of the first differences. In order to induce stationarity (at a 95% level of confidence) first differences are required for the land price index and second differences for the house price index. The house price index is stationary at second differences with a 99% level of confidence (Table 1). The Akaike Information Criterion (AIC) indicators recommend a 3 lag structure for the first difference model of the land price index and a 6 lag structure for the second difference model of the house price index.

Table 1 - Augmented Dickey-Fuller test

| Time Series | Ordinary data (Level) | First Differences | Second Differences | AIC recommended Lag length |
|---|---|---|---|---|
| Land Price Index | 5.93 | -2.86*** | - | Lag Length 3 (1st diff model) |
| House Price Index | 1.87 | -1.70* | -5.40*** | Lag Length 6 (2nd diff model) |

*** Significant at 99% -critical value -2.59
** Significant at 95% -critical value -1.94
* Significant at 90% -critical value -1.1

## Johansen Cointegration Test

As the ADF test shows that the data is not stationary without differencing, the Johansen test is used to establish if the data is cointegrated. If it is cointegrated then the cointegrating equation can be considered as a long-run equilibrium relationship between the land and house price indexes.

Table 2 - Johansen Cointegration Test

| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | Prob. | Max-Eigen Statistic | Prob.** |
|---|---|---|---|---|---|
| None * | 0.117504 | 13.96460 | 0.0263 | 12.37516 | 0.0313 |
| At most 1 | 0.015927 | 1.589438 | 0.2434 | 1.589438 | 0.2434 |

Trace test indicates 1 cointegrating equation at the 0.05 level denotes rejection of the hypothesis at the 0.05 level MacKinnon-Haug-Michelis (1999) p-values

The Johansen test is indicated in Table 2 and shows the eigenvalue and trace statistics. The trace test indicates one integrating equation and supports the cointegration of the two indices at a 95% level.

## Vector Error Correction Model and Granger Causality

In the presence of cointegration, the Granger causation test cannot be estimated in a simple VAR model but requires the model to be specified in the more restricted vector error correction (VEC) framework. In the VEC model the long-run relationships between the land and house price index should converge and the short-run variations can be examined through the correction coefficients which measure the speed of adjustment between the two series. The VEC model is estimated using the number of lag periods suggested by the AIC approach without a deterministic trend and the results are indicated in Table 3.

Table 3 - Vector Error Correction model

| Cointegrating Eq: | CointEq1 | |
|---|---|---|
| HPI(-1) | 1.000000 | |
| LPI(-1) | -1.419270 | |
| Error Correction: | ΔHPI | ΔLPI |
| CointEq1 | -0.0055*** | -0.0051*** |
| ΔHPI(-1) | 0.2023 | 0.4371 |
| ΔHPI(-2) | 0.37670 | 0.5665 |
| ΔHPI(-3) | -0.0559 | 0.0019 |
| ΔHPI(-4) | 0.2524 | 0.3856 |
| ΔHPI(-5) | 0.1041 | 0.1719 |
| ΔHPI(-6) | -0.1640 | -0.5361 |
| ΔHPI(-7) | -0.0488 | 0.3171 |
| ΔHPI(-8) | 0.2757 | -0.0598 |
| ΔLPI(-1) | -0.0614** | -0.5735 |
| ΔLPI(-2) | -0.0214** | 0.0074 |
| ΔLPI(-3) | -0.0077** | 0.0238 |
| ΔLPI(-4) | -0.0904** | 0.0312 |
| ΔLPI(-5) | -0.0864** | 0.0820 |
| ΔLPI(-6) | -0.1081** | 0.0723 |
| ΔLPI(-7) | -0.0411** | -0.0255 |
| ΔLPI(-8) | 0.0324** | -0.0182 |
| R-squared | 0.4531 | 0.4152 |
| Adj. R-squared | 0.3380 | 0.2921 |
| Sum sq. resids | 0.0238 | 0.1826 |
| S.E. equation | 0.0177 | 0.0490 |
| F-statistic | 3.9368 | 3.3735 |
| Log likelihood | 252.60 | 157.86 |
| Akaike AIC | -5.0667 | -3.0293 |
| Schwarz SC | -4.6037 | -2.5663 |

*** Significant at 99%

** Significant at 95%

The causal relationship between house price and land price has been tested using the VEC Granger causality/block erogeneity Wald test with the results shown in Table 4.

Table 4 - VEC Granger Causality - Wald tests

| Dependent variable: ΔHPI | | | |
|---|---|---|---|
| Excluded | Chi-sq | df | Prob. |
| ΔLPI | 12.003 | 8 | 0.1510 |
| Dependent variable: ΔLPI | | | |
| Excluded | Chi-sq | df | Prob. |
| ΔHPI | 16.955 | 8 | 0.0306** |

** Significant at 95%

## CONCLUSION

This paper has presented details of the construction of a Site Adjusted Land Price Index which has allowed for a consistent analysis of the relationship between house and land price change over time. Lead lag analysis of the land index using the VEC model against a Quality Adjusted House Price Index shows the error correcting coefficient to be significant in both models and supports the proposition that these two variables are cointegrated (Engle & Granger 1987; Luo et al 2007). The Wald test shows that there is support for the proposition that House Prices Granger causes land prices but not that Land Prices Granger causes house prices. Where change in the house price index is the dependent variable the Wald test fails at even a 90% confidence level. However in the equation where change in land price index is the dependent variable change in house price index is significant at 95%. This then supports the Ricardian land rent hypothesis that an increase in prices for established properties causes an increase in the residual value of land for developers and hence drags land prices upwards through demand by developers. Developers will not pay more for land than that which accords with the going rate of established house prices. At least in the short run. This is consistent with similar work by Ooi and Lee (2007) for Singapore and is an important empirical finding for the Australian housing and land market.

However in contrast to the Singapore findings the results for Adelaide show that there is a lagged effect of land prices on house prices and that this is significant at an interval of 8 lag periods. This suggests that while a change in house prices leads to a change in land prices in the short run the long run position is for increasing land prices to lead to a delayed increase in house prices. This is consistent with the classic view of economic substitution where buyers see the inflated cost of new houses (due to increase land prices in previous periods) as a substitute for increased established houses prices. It is also consistent with developers anticipating higher house prices through strong demand and accentuated by land constraints (Adams et al 2009). Also in contrast to the Singapore findings the response to deviations from the long-run equilibrium is extremely slow in both the Adelaide house and land markets. Both show significant corrections in the next period but these are in the order of 1%. There are two possible explanations for this. Prices in the Adelaide house market, over the period from 1985 to 2010, have shown an almost continuous progression with almost no negative differences and the market is notoriously sticky with prices continuing to rise prior to and after the GFC in 2008 through 2010. While market values may drop considerably very few owners sell houses (or land) in periods of economic downturn preferring to hold on their property rather than face an economic loss by reducing their prices. The high level of low-density development with a myriad of micro-developers means that few developers are exposed to significant losses though holding assets and hence few properties transact in down periods as owners and developers decide to “wait out” any crisis.

Thus the relationship between house prices and land prices is not necessarily one way. There are suggested effects both immediate from house to land and delayed from land to house particularly in a rising market. Thus competition for land amid developer expectations of rising house prices may impact on housing affordability and are important elements for policy setting. As illustrated by comparison of the house price and land price indexes there can be no doubt about the rising cost of vacant land in Adelaide relative to detached dwellings on improved sites. However further work on developer behaviour within Australia, especially with respect to the dynamic of market cycles and the importance of current versus forecast housing values within the framework of planning policy, is required to augment these suppositions.

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**APPENDIX**

## Figure 2 - Correlogram Ln House Price Index – original data - on the level

Sample: 1985Q1 2010Q2

Included observations: 102

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| .\|******* | .\|******* | 1 | 0.970 | 0.970 | 98.804 | 0.000 |
| .\|******* | .\|. \| | 2 | 0.940 | -0.019 | 192.45 | 0.000 |
| .\|******* | .\|. \| | 3 | 0.909 | -0.020 | 281.00 | 0.000 |
| .\|******\| | .\|. \| | 4 | 0.879 | -0.012 | 364.58 | 0.000 |
| .\|******\| | .\|. \| | 5 | 0.847 | -0.042 | 443.02 | 0.000 |
| .\|******\| | .\|. \| | 6 | 0.814 | -0.037 | 516.21 | 0.000 |
| .\|******\| | .\|. \| | 7 | 0.779 | -0.053 | 583.92 | 0.000 |
| .\|***** \| | .\|. \| | 8 | 0.743 | -0.035 | 646.17 | 0.000 |
| .\|***** \| | .\|. \| | 9 | 0.706 | -0.034 | 703.01 | 0.000 |
| .\|***** \| | .\|. \| | 10 | 0.667 | -0.055 | 754.32 | 0.000 |
| .\|***** \| | .\|. \| | 11 | 0.628 | -0.019 | 800.35 | 0.000 |
| .\|**** \| | .\|. \| | 12 | 0.593 | 0.027 | 841.75 | 0.000 |
| .\|**** \| | .\|. \| | 13 | 0.558 | -0.002 | 878.86 | 0.000 |
| .\|**** \| | .\|. \| | 14 | 0.524 | -0.012 | 911.92 | 0.000 |
| .\|**** \| | .\|. \| | 15 | 0.490 | -0.017 | 941.14 | 0.000 |
| .\|*** \| | .\|. \| | 16 | 0.458 | 0.023 | 967.03 | 0.000 |
| .\|*** \| | .\|. \| | 17 | 0.427 | -0.020 | 989.75 | 0.000 |
| .\|*** \| | .\|. \| | 18 | 0.396 | -0.010 | 1009.6 | 0.000 |
| .\|*** \| | .\|. \| | 19 | 0.365 | -0.047 | 1026.6 | 0.000 |
| .\|** \| | .\|. \| | 20 | 0.333 | -0.018 | 1040.9 | 0.000 |

## Figure 3 - Correlogram Ln House Price Index – original data - first differences

Sample: 1985Q1 2010Q2

Included observations: 101

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| .\|*** \| | .\|*** \| | 1 | 0.377 | 0.377 | 14.762 | 0.000 |
| .\|*** \| | .\|*** \| | 2 | 0.465 | 0.376 | 37.446 | 0.000 |
| .\|** \| | .\|. \| | 3 | 0.221 | -0.041 | 42.629 | 0.000 |
| .\|*** \| | .\|** \| | 4 | 0.397 | 0.242 | 59.565 | 0.000 |
| .\|* \| | .\|. \| | 5 | 0.212 | -0.001 | 64.417 | 0.000 |
| .\|* \| | *\|. \| | 6 | 0.160 | -0.147 | 67.205 | 0.000 |
| .\|. \| | .\|. \| | 7 | 0.064 | -0.039 | 67.656 | 0.000 |
| .\|** \| | .\|* \| | 8 | 0.228 | 0.202 | 73.451 | 0.000 |
| .\|* \| | .\|. \| | 9 | 0.099 | -0.047 | 74.557 | 0.000 |
| .\|* \| | .\|. \| | 10 | 0.124 | -0.017 | 76.322 | 0.000 |
| .\|. \| | .\|. \| | 11 | -0.008 | -0.038 | 76.329 | 0.000 |
| .\|* \| | .\|* \| | 12 | 0.194 | 0.145 | 80.749 | 0.000 |
| .\|. \| | *\|. \| | 13 | -0.014 | -0.167 | 80.773 | 0.000 |
| .\|* \| | .\|* \| | 14 | 0.140 | 0.105 | 83.127 | 0.000 |
| .\|. \| | .\|. \| | 15 | -0.007 | 0.052 | 83.133 | 0.000 |
| .\|* \| | .\|. \| | 16 | 0.165 | 0.014 | 86.462 | 0.000 |
| .\|. \| | .\|. \| | 17 | 0.022 | -0.049 | 86.521 | 0.000 |
| .\|. \| | *\|. \| | 18 | 0.028 | -0.079 | 86.617 | 0.000 |
| .\|. \| | .\|. \| | 19 | -0.062 | -0.049 | 87.098 | 0.000 |
| .\|. \| | .\|. \| | 20 | 0.046 | 0.013 | 87.367 | 0.000 |

## Figure 4 - Correlogram Ln Land Price Index – original data - on the level

Sample: 1985Q1 2010Q2

Included observations: 102

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| .\|******* | .\|******* | 1 | 0.972 | 0.972 | 99.181 | 0.000 |
| .\|******* | .\|. \| | 2 | 0.945 | 0.019 | 193.99 | 0.000 |
| .\|******* | *\|. \| | 3 | 0.915 | -0.086 | 283.68 | 0.000 |
| .\|******\| | .\|. \| | 4 | 0.886 | 0.014 | 368.72 | 0.000 |
| .\|******\| | .\|. \| | 5 | 0.858 | 0.003 | 449.29 | 0.000 |
| .\|******\| | *\|. \| | 6 | 0.826 | -0.091 | 524.74 | 0.000 |
| .\|******\| | .\|. \| | 7 | 0.795 | -0.013 | 595.29 | 0.000 |
| .\|******\| | .\|. \| | 8 | 0.763 | -0.021 | 660.92 | 0.000 |
| .\|***** \| | .\|. \| | 9 | 0.732 | 0.015 | 722.12 | 0.000 |
| .\|***** \| | .\|. \| | 10 | 0.701 | -0.041 | 778.78 | 0.000 |
| .\|***** \| | .\|. \| | 11 | 0.670 | -0.003 | 831.18 | 0.000 |
| .\|***** \| | .\|. \| | 12 | 0.639 | -0.029 | 879.31 | 0.000 |
| .\|**** \| | .\|. \| | 13 | 0.611 | 0.045 | 923.83 | 0.000 |
| .\|**** \| | .\|. \| | 14 | 0.581 | -0.056 | 964.56 | 0.000 |
| .\|**** \| | .\|. \| | 15 | 0.553 | 0.007 | 1001.9 | 0.000 |
| .\|**** \| | .\|. \| | 16 | 0.523 | -0.048 | 1035.6 | 0.000 |
| .\|**** \| | .\|. \| | 17 | 0.494 | 0.000 | 1066.1 | 0.000 |
| .\|*** \| | *\|. \| | 18 | 0.462 | -0.082 | 1093.0 | 0.000 |
| .\|*** \| | .\|. \| | 19 | 0.430 | -0.014 | 1116.7 | 0.000 |
| .\|*** \| | .\|. \| | 20 | 0.399 | -0.022 | 1137.3 | 0.000 |

## Figure 5 - Correlogram Ln Land Price Index – original data - first differences

Sample: 1985Q1 2010Q2

Included observations: 101

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| ***\|. \| | ***\|. \| | 1 | -0.474 | -0.474 | 23.384 | 0.000 |
| .\|** \| | .\|* \| | 2 | 0.328 | 0.133 | 34.693 | 0.000 |
| *\|. \| | .\|* \| | 3 | -0.140 | 0.076 | 36.779 | 0.000 |
| .\|* \| | .\|* \| | 4 | 0.145 | 0.089 | 39.023 | 0.000 |
| .\|. \| | .\|* \| | 5 | -0.007 | 0.107 | 39.029 | 0.000 |
| .\|. \| | .\|. \| | 6 | 0.038 | 0.047 | 39.184 | 0.000 |
| .\|. \| | .\|. \| | 7 | -0.019 | -0.022 | 39.223 | 0.000 |
| .\|. \| | *\|. \| | 8 | -0.013 | -0.066 | 39.243 | 0.000 |
| .\|. \| | .\|. \| | 9 | 0.021 | -0.018 | 39.292 | 0.000 |
| .\|. \| | .\|. \| | 10 | 0.011 | 0.030 | 39.306 | 0.000 |
| *\|. \| | *\|. \| | 11 | -0.095 | -0.110 | 40.340 | 0.000 |
| .\|. \| | *\|. \| | 12 | 0.002 | -0.104 | 40.340 | 0.000 |
| .\|. \| | .\|. \| | 13 | 0.006 | 0.024 | 40.344 | 0.000 |
| *\|. \| | *\|. \| | 14 | -0.091 | -0.084 | 41.330 | 0.000 |
| .\|* \| | .\|* \| | 15 | 0.160 | 0.141 | 44.425 | 0.000 |
| *\|. \| | .\|* \| | 16 | -0.085 | 0.129 | 45.314 | 0.000 |
| .\|. \| | *\|. \| | 17 | -0.007 | -0.072 | 45.321 | 0.000 |
| .\|* \| | .\|. \| | 18 | 0.076 | 0.072 | 46.053 | 0.000 |
| .\|. \| | .\|* \| | 19 | -0.001 | 0.077 | 46.054 | 0.000 |
| .\|. \| | .\|. \| | 20 | 0.002 | -0.040 | 46.054 | 0.001 |